Behavior of Tritium in Oxide Film of Stainless Steel

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Austenitic stainless steels are widely used as structural materials of tritium systems. Behavior of tritium in oxide films is important problem closely related to surface contamination, permeation, and release of tritium. It is known that tritium is highly enriched in the surface oxide layers of contaminated type 316 stainless steel (SS316) [1,2]. Factors controlling the tritium concentration in the oxide films, however, have not been fully understood. The objective of the present study is to examine the correlation between Cr content and tritium concentration in oxide films.

Three types of SS316 specimens having different Cr content in oxide films were used: a specimen under as-received conditions, that polished with colloidal silica, and that covered by Cr_2O_3 layer formed by heating in Ar gas containing H_2 and O_2. Specimens of pure Fe were also prepared. These specimens were exposed to tritium gas diluted with deuterium ([T]/[D] = 0.005) at 573 K and 1.2 kPa for 3 h. The amounts of tritium in oxide films were measured with an imaging plate (IP), and the tritium concentration in oxide films was evaluated by dividing the intensity of photo-stimulated luminescence from IP by thickness of oxide films measured by glow discharge optical emission spectroscopy. The specimens were also analyzed with X-ray photoelectron spectroscopy to examine Cr content in the oxide layer, and concentration of hydroxyl species from the chemical shift in O1s photoelectron spectrum. The tritium concentration in oxide films thus evaluated showed clear correlation with Cr content, and it decreased with increasing Cr content in the oxide films. The concentration of hydroxyl species showed similar dependence on Cr content. It was therefore concluded that tritium was mainly present as hydroxyl species in the oxide films, and smaller concentration of hydroxyl species in Cr-rich oxide films resulted in smaller tritium concentration. Thin, and Cr-rich oxide films appear to be suitable to reduce surface contamination.

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